بسم الله الرحمن الرحيم

❖ Blood Physiology ❖

① Introduction of the blood

➤ Components:

I. Red blood cells (RBCs) OR erythrocytes.
II. White blood cells (WBCs) OR Leukocytes
III. Platelets OR thrombocytes
IV. Plasma.

➤ Functions:

I. Respiratory
II. Transport of nutrients.
III. Transport of waste products (Urea).
IV. Transport of hormones.
V. Regulation of body fluid.
VI. Regulation of body temperature.
VII. Defense.
VIII. Haemostasis.

➤ Properties:

I. Specific gravity: "1.052 - 1.061"
   ✓ Plasma 55%.
   ✓ Cells 45%.
II. Osmolarity
III. Viscosity: "2-3" time water.
   - Due to presence of plasma protein and RBCs.
IV. pH: "7.35 - 7.45".

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② Red blood cells "RBCs":

➤ Characteristics:

- Shape: small & bioconcave.
- Diameter: 8 Micrometer.

- Thickness: 1-2 Mm
- Volume: 85-90 Cu Mm.
- Surface area: 138 Sq Mm.

Benifits of Biconcave Shape:

- ✓ diffusion of oxygen.
- ✓ Help passage of RBCs through narrow capillaries.
- ✓ with Stand osmotic Pressure.

Count:

- Male = $5.2 \times 10^6/mm^3$.
- Female = $4.7 \times 10^6/mm^3$

Hb Concentration:

- ✓ Male: 14-16 gm/100 ml
- ✓ Female: 12-14 gm/100 ml.

PCV (Packge Cell Volume):

- ✓ Male: 47% (40-50%).
- ✓ Female: 42% (37-47%).

Indices:

(1) M.C.V (Mean Cell Volume) = $\frac{P.C.V}{RBCs} \times 10$ = 90 Cu Mm.

(2) M.C.H (Mean Cell Hb) = $\frac{Hb}{RBCs} \times 10$ = 30 picogram.

(3) M.C.H.b (Mean cell concentration) = $\frac{Hb \times 100}{P.C.V}$.

- ✓ Hb 15 gm/ml of blood.

Formation (Erthropoiesis):

Site of formation:

(A) 3 month → Yolk sac.

(B) 3-7 month → Liver & spleen.

(C) 4-9 month → Bone marrow.

- ✓ after birth only the bone marrow formed the RBCs.
- ✓ 20 Years only flat bones:

  Skull, Ribs, Sternum & Vertebra.

  Yellow marrow inactive.

Stages of formation :

1. Cell become smaller
2. Nucelus become smaller & finally disapear.
3. More formation of Hb.

Control of RBCs formation :

- Need of tissue for oxgen.
- Hypoxia : is decrease in oxgen in tissue.
- Hypoxia of kidney → Esthyropoitein → Blood → Bone marrow to form the RBCs.

Erythropoiteim :

- ✓ early Stages
- ✓ Start Hb formation
- ✓ Doesn't affect WBCs & Platelets formation.
- ✓ Increase DNA & RNA.
- ✓ Only kidney 90 % & Liver 10 %.

Substances needed to formation of RBCs :

1. Protein.
2. Vitamins :
   - A) Vitamins B_{12}, folic acid B) Vitamin B_6
   - C) Vitamin C D) Vitamin B complex E) Vit E
3. Trace elements (metals).
4. Iron.

Remember the stages of formation of RBCs :

1. Stem Cells 2. Comitted stem cell
3. Pronormoblast 4. early normoplast
5. Intermediate normoblast 6. btenormoblast.
7. Reticulocyte.

Vitamins :

1. B12 & Folic acid :
   Formation of DNA & RNA (cell division).

✓ Deficiency of B_{12} Causes:

① Number is decreased ② Large cells (megaloblast)
③ Deformed ④ Fragile (easly break)

(2) Vit B_6:

Haem, DNA.

(3) Vit C:

Absorption of iron, folic acid metabolism.

(4) Vit B complex:

Protein, Thiamin N.A

(5) Vit E:

Needed for formation of the cell membrane especially in infants.

Trace elements:

Copper, Cobalt, Zn, Mn and Nickel

Iron:

without Fe hemoglobin can not carry oxygen

Distribution: Total amount 4-5 gm.

Ⓐ Hb (70%) 3000 mg.

✓ 1 ml. of RBCs = 1 mg of iron.

Ⓑ Store:

✓ Liver (20%) = 1000 mg.

✓ apoferritin + Fe = Ferritin (⅔). (Soluble).

✓ Haemosidrin (insoluble) is ferritin loss its amino-acid & it consist of one third (⅓).

Ⓒ Cellular iron: 150 mg.

✓ Myoglobin (skeletal & cardiac muscle).

✓ Intracellular enzyme (cytochrome)

Ⓓ Transport Fe: 3-4 mg.

✓ apotransferrin + Fe → Transferrin → Bone marrow. Stores

Requirements :

1. Meat
2. Vegetables

- ✓ Milk contain no iron
- ✓ Males = 10 mg Fe/day.
- ✓ Females = 20 mg Fe/day.
- ✓ Important for growth in children.

Absorption :

- ✓ 10 % in food.
- ✓ 1mg in male & 2 mg in female.

Factors affecting absorption :

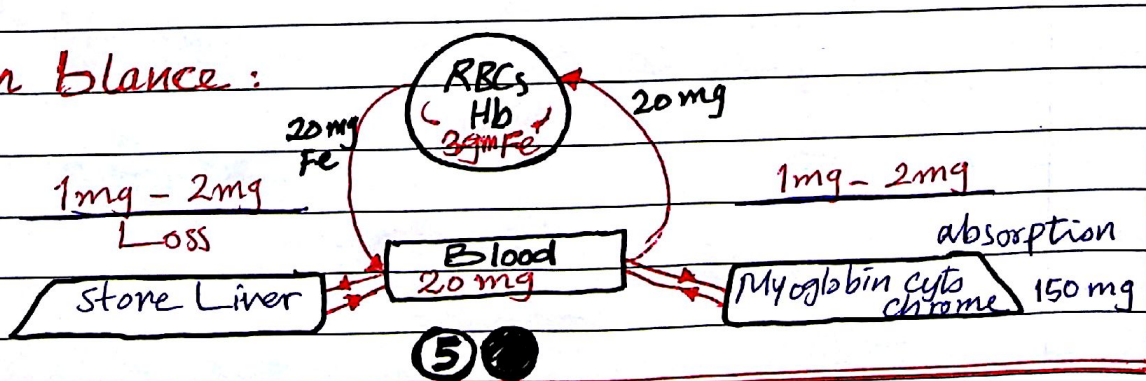
1. site : Duodenum & upper jejenum
2. $Fe^{+++} \xrightarrow[HCl]{VitC} Fe^{++}$
3. Phosphate, oxalates and tenates insoluble compounds with iron.
4. Whole haeme part absorbed.
5. Decrease Stores → Increase absorption 6 % in Male and 14 % in female and 20 % in anaemic

Iron Loss :

- ✓ In Males = 1mg/day.
- ✓ In Females = 2mg/day.

1. Faeces
2. Skin skin cells, hair, nails and sweat.
3. Urine "negligible".

Iron balance :



RBCs Break down:

(1) Jaundice: Yellowish colour in the skin.

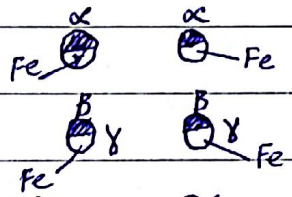
* Types:

(i) Pre hepatic.
- ✓ haemolysis.
- ✓ Spherocytosis.

(ii) Hepatic.
- ✓ Liver disease

(iii) Post hepatic.

* Haemoglobin:



- ✓ Hb A: 96% ($\alpha - \beta$)
- ✓ HbA_2: 2% Delta chain
- ✓ HbF: 2% γ chain $1\alpha - 2\gamma$

Why Hb found inside RBCs and NOT in Plasma freely ???

1. Osmotic pressure.
2. Viscosity of plasma (blood pressure).
3. Taken by macrophagus and destroyed.
4. Excreted in urine.

(2) Anaemia: Decrease of Hb Concentration.

* Classification according to cause:

(1) Blood loss:

(A) Acute: plasma → (1-3) days.
RBCs → (3-4) weaks.

(B) Chronic blood:

Can not absorb enough iron and the iron it is the most common anaemia in the world; the cells will be microcytic-hypochromic.

(2) Decreased formation of RBCs:

* Increase need of RBCs:

(A) Pregenancy (B) Destruction

(C) Children fed with milk only.

(3) Maturation failure:

(A) Large (Macrocytic) (B) Number decrease

(C) Deformed. (D) Fragile.

(4) Haemolytic anaemia:

✓ Intracellular

✓ Spherocytosis in Shape.

✓ Structure of Hb abnormal:

a) Sickle cell b) Thalassamia.

✓ Extracellular.

* Polycythaemia:

Increase in Hb concentration and RBCs Count ↑ 5×10^6 / cu mm.

✓ Block capillaries.

✓ Resistance to flow → ↑ blood pressure.

✓ True: at the high altitude.

✓ Relative:

Dehydration.

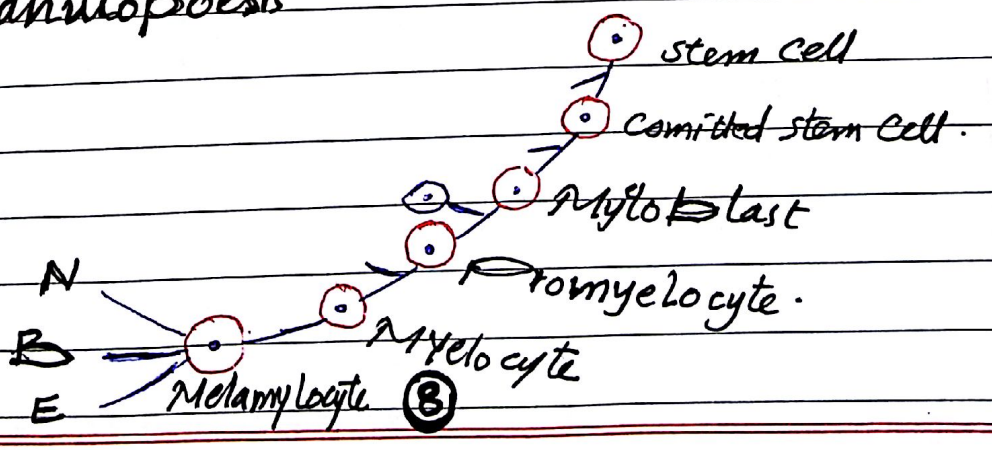
③ White blood cell (WBCs) :

- Classification :
  - A) According to the function :
    - ✓ Phagocytes :
      - Neutrophils.
      - Eosinophils.
      - Basophils.
      - Monocytes.
    - ✓ Immunocytes :
      - Lymphocytes.
  - B) Morphological :
    - ✓ Granulocytes.
    - ✓ Agranulocytes.

- Total Leukocytes Count :
  - 3000 - 10 000 cu/mm

- Defferential Leukocyte Count (DLC)
  - Neutrophils : 60 - 70 %
  - Lymphocytes : 20 - 30 %
  - Eosinophils : 2 - 4 %
  - Basophils : 0 - 2 %
  - Monocytes : 2 - 8 %

- Granulopoesis



Life span:

- Granulocyte:
  - ✓ Blood: 7–10 hours
  - ✓ Tissue: few days.
- Monocyte:
  - ✓ Tissue: 7–10 hours
  - ✓ Macrophages: 1 Year.
- Lymphocyte:
  - ✓ T-lymphocyte 100–300 days
  - ✓ B-lymphocyte: 7 days.

Neutrophils

properties:

(1) Chemotaxis: ability of neutrophil to be attracted to area of microorganism.

- ✓ Chemotatic agent:
  - a. Taxis of microorganism
  - b. Damged leukocyte.
  - c. Dead tissue.
  - d. Clotting mechanism.

(2) Margination: ability of neutrophil to stick margin of blood vessel.

(3) Diapedesis: ability of neutrophil to squeeze and go out between endothelial cells.

(4) Amoeboid movement.

(5) Phagocytosis

(A) Recoginition:

- ✓ Antibodies marking microorganism.
- ✓ Rough Surface.
- ✓ Electropositive charge

(B) Phagocytosis

(C) Killing (D) Digestion.
(E) Dead neutrophils are phagocytosed by macrophages.

Monocyte

- Component of macrophages system:
  (1) Blood monocyte.
  (2) Tissue macrophages.
  (3) Reticular cells of spleen, bone marrow & lymph nodes.
  (4) Endothelial cells covering blood sinuses and lymph sinuses.
- Function:
  ① Phagocytosis.
  ② Break down of Hb.
  ③ Stored of iron.
  ④ Help the immune system.

Eosinophil

- ✓ Substances that inactive Histamine
- ✓ Major basic protein → Kills parasite.
- ✓ Weak phagocytosis.
- ✓ In microscope shows as Red colour.
- ✓ Limit allergy.
- ✓ Increase in allergy & parasite infection.

Basophil

- ✓ Heparin (anticoagulant).
- ✓ Histamin (allergy), but to warring other cells.

➢ **Leukocytosis**: Increase in number of RBCs.

- **Types of Leukocytosis**

1. **Physiological**:
   a. Diurnal variation (↑) in afternoon.
   b. Exercise.
   c. After protein meal.
   d. Adrinary stress.
2. **Pathological**:
   a. Neutrophil (↑): bacterial infection
   b. Eosinophil (↑): Allergy & parasitic infection.
   c. Basophil (↑): Allergy.
   d. Monocyte (↑): Chronic infection e.g (T.B).
   e. Lymphocyte (↑): Viral infection & chronic infection.

➢ **Leukopenia**: Decrease in number of WBCs.

- ✓ Typhoid fever.
- ✓ Vit B_{12} & Folic acid.
- ✓ Severe mal-nutrition.

➢ **Leukaemia**: Increase of the number of WBCs. and the cells are not mature.

- ✓ Anaemia + bleeding problems.
- ✓ The body become weak.
- ✓ Can not defense the body.

IMMUNITY:

1. **Natural (innate)**.
   a. Allways present.
   b. General
   - **Examples**:
     [i] phagocytes (Neutrpil/Monocyte) [ii] HCl in stomach
     [iii] blood Lysozymes [iv] Skin barrier.

23 Aquired immunity

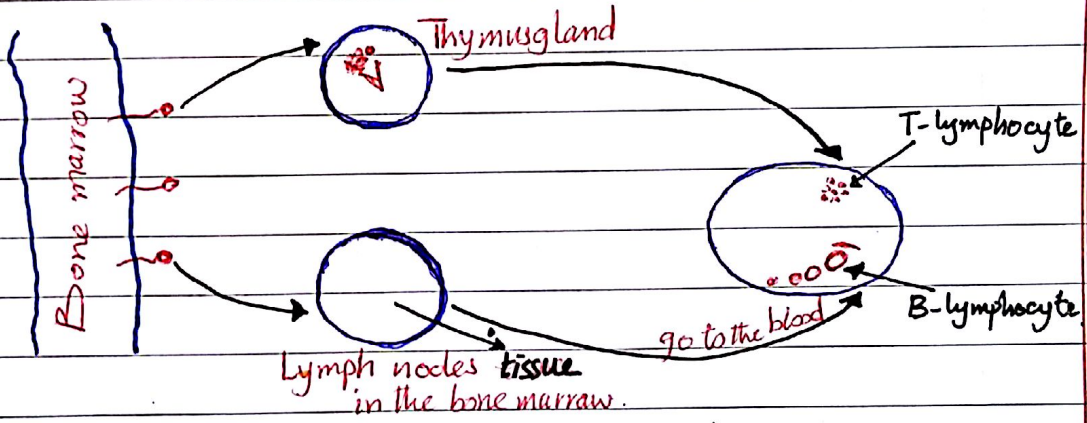
- specific triggered by forgin particle and destroy only that foreign

Ⓐ Cellular immunity ◀ T-lymphocytes ▶
Ⓑ Humeral immunity ◀ B-lymphocyte ▶

• Antigen :

Substance that stimulates immune system T or B - lymphocyte to produce responses. and it can be :

Ⓐ protein Ⓑ glycoprotein
Ⓒ part of microorganism Ⓓ Transplanted organ.



It can be move to the blood and return to the lymph node.

✓ For antigen:

- T-lymphocytes : divided
- B-lymphocyte : Stages ○○○○○

. (Antibody) = plasma cell (protein)

• Antibodies :

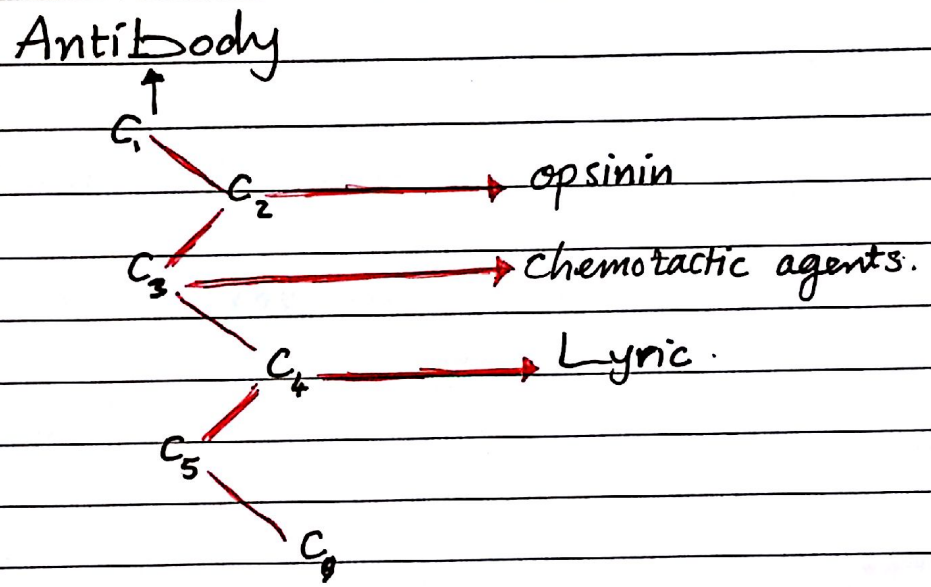
(Immunoglobin)

1. Ig G (IgG_1 ⟶ IgG_4) 80 %
2. Ig A - IgA_2
3. Ig M
4. Ig E ⟶ allergy.
5. Ig D

• Mechanism of action of antibody :

1. Direct :
   - a. Agglutination
   - b. precipitation (Soluble antibody → insoluble)
   - c. Nutralization : Cover the toxic part.
   - d. Lysis
2. Indirect :

enzym inactive



✓ The indirect way is more important than the direct way.

• Cellular immunity :

✓ Produced by T-lymphocyte.

✓ Types :

1. Helper T-lymphocyte 75% of the total.
2. Killer T-lymphocyte (cytotoxic)
3. Suppressor (inhibitor).

1. Helper T-lymphocyte :

A. Stimulate B-lymphocyte → antigen.

B. Stimulate killer cells → kill.

C. Stimulate microphages ⟶ phagocytosis.

☺ Lymphokines (cytokines) that stimulate the helper T-lymphocyte.

② Killer T-lymphocyte:

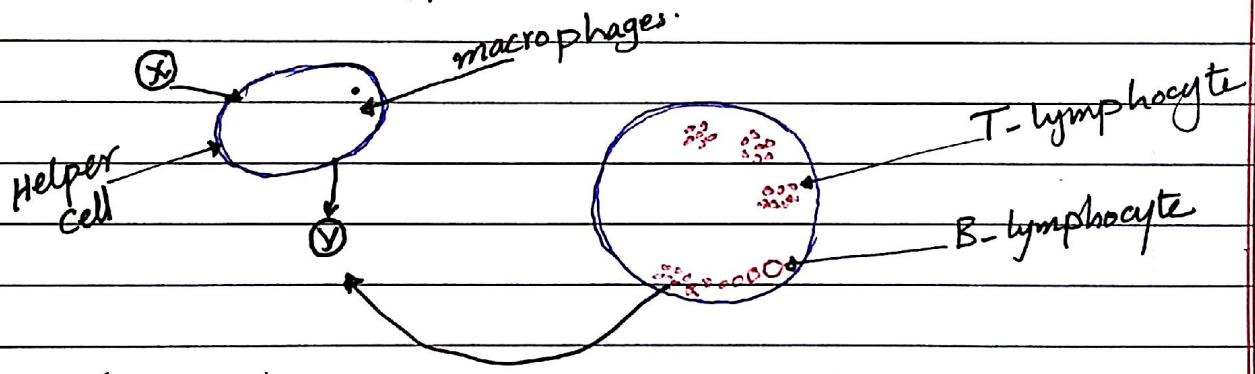
③ Suppressor:

Limit the function of helper & killer T-lymphocyte.

- In the normal person:
  - Helper : suppressor (1 : 1).

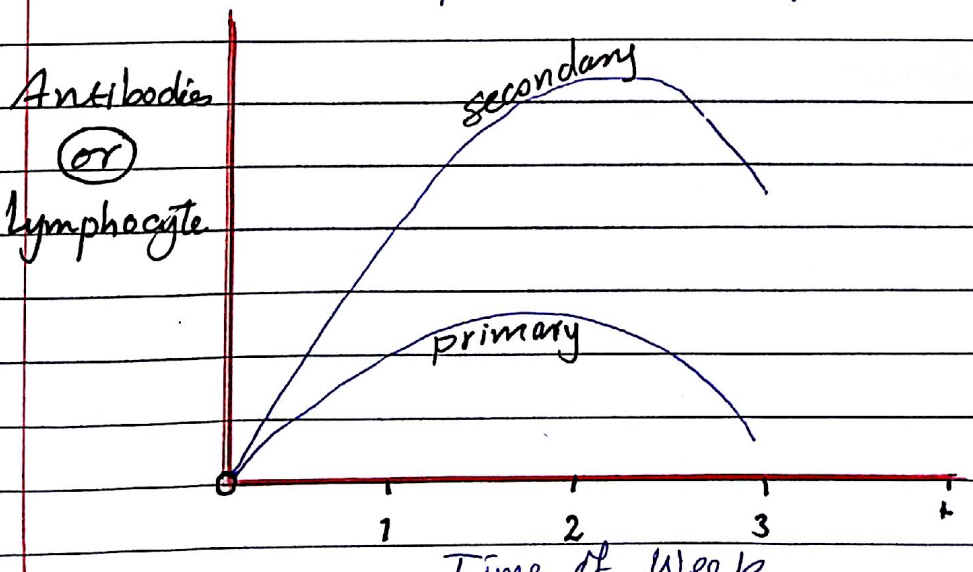
But in HIV:

- Helper : suppressor (1 : 2).



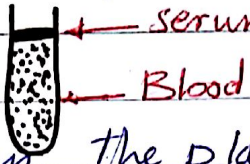
✓ Primary immune response.

✓ Secondary immune response.



④ Plasma :

✓ Yellow in colour.
✓ Contain water, electrolyte
✓ Plasma can clot



- The different between the plasma and the serum :
  serum = plasma − clotting factor

▸ Plasma protein : (7-8 g/100 mL L).

1. Albumin = 4.5 g/100 mL
   - M.W = 69.000
2. Globulin = 2.5 g/100mL L
   - M.W = 90,000 - 140.000
   - Liver (2α, 2β & γ) lymph node
3. Fibrinogen = 0.3 g/100ml
   M.W = 340,000

✱ Function of plasma protein :

① Exchange in the fluid between capillaries and interstitial fluid, due to osmotic & oncotic.
② Transport of hormones from the endocrine gland to the target organ.
③ Transport of waste products.
④ Transport of Carbon dioxide.
⑤ Replacement of the lost tissue protein.
⑥ Blood coagulation.
⑦ Defense.
⑧ Buffer.

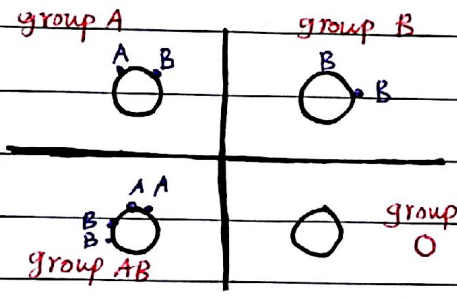
Blood group :

- Donor ⟹ gives.
- Recipient ⟹ recived

✓ Tow things will occur if we give blood to recipient:

1. Nothing match
2. severe reaction.

① ABO system :



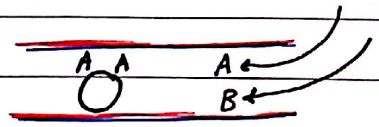
phenotype	Genotype
A	AA / AO
B	BB / BO
AB	AB
O	OO

② if the father group A & Mother B . The possible children BG will be: (AB) or (AO) or (Bo) or (OO)

✓ How the antibodies forms ??

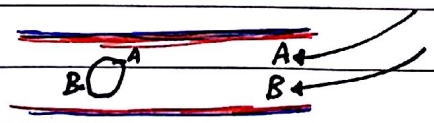
- Antibody (agglutinin)
- Antigen (agglutinogen).

ⓐ



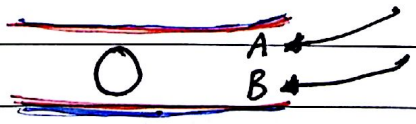
The body forming anti B

ⓑ



Has no antibodies from A and B.

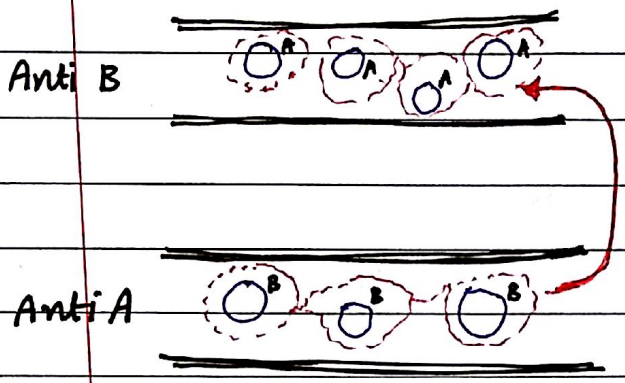
ⓒ



The body forming anti A and B.

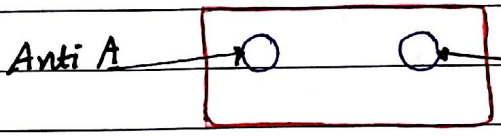
d

The body forming anti A

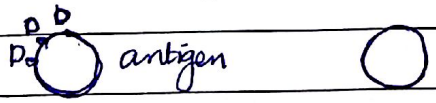


- Donors RBCs usually agglutinated by antibodies of the recipient :
  - ✓ Group (O) is Universal donor.
  - ✓ Group (AB) is Universal recipient.
  - ✓ 50% Group (O)
  - ✓ 3% Group (AB)

- How to Knows the blood group ?



② Rhesus system :

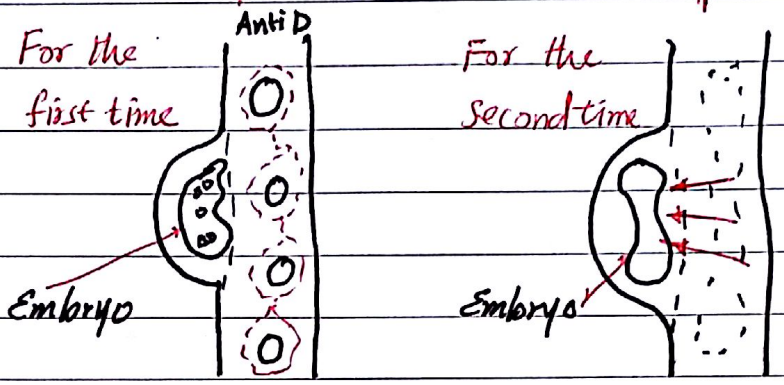


RH (+ve) (RH-ve).

- ✓ Only by blood transmition we can form anti D.
- ✓ Antigen D (+ve) is 90%.
- ✓ Antigen D (-ve) is only 10%.

Haemolytic Disease of newborn:

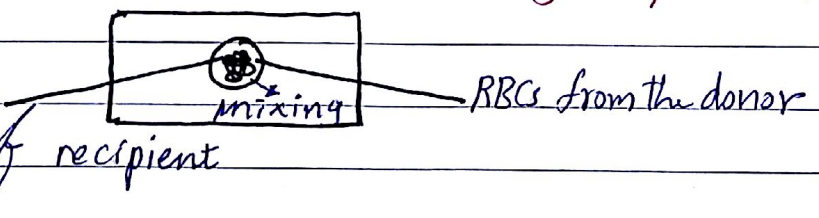
Father	Mother	Fetus
Rh +ve	Rh -ve	Rh +ve



- The first fetus will be fine but the second will borne with:
  a. Anaemia b. Juandice.
- To the fetus:
  exchange transimition: take out the blood of new born and give him Rh-ve from the other side.

Blood transfusion:

- precaution:
  1. give the person his own blood.
  2. Emergency we can give blood group O.
  3. Cross matching.
     ((Take serum from recipient & mixing RBCs of donor))



  4. Blood of donor Screened for HIV and hepatitis.

Hemostasis:

- Prevention of blood Loss.

1. Vasoconstriction (Vasospasm) 2. formation of platelet plug.
3. blood coagulation 4. fibrinolysis.

Mechanism of Vasospasm:

1. Platelets secrete vasoconstriction.
   - [a] 5 hydroxy tryptamine (5HT) [b] Thromboxane A_2 (TA_2)
2. Stretch of smooth muscle cause contraction (myogenic)
3. Pain stimulate → S.N.S → Noradrenaline

Formation of platelet plug:

- Stem cell → megakaryoblast → promegakaroblot → Megakaryocyte:
  - Diameter: 1-2 Mm Volume: 5-8 cuMm
  - Number: 150000 - 400000 cuMm Averag: 250.000.CuMm

✓ During wounds Level:

✓ Things will occurs:

1. Swell 2. irregular shape 3. Sticky 4. secrete →
   - a. 5HT → vasconstriction b. TA_2 → Vasconstriction + aggregation
   - c. ADP → aggregation d. Heparin → Neutralizing factor.
   - e. platelet phosphatinicl → blood clotting f. Von-willibrand factor → attached platelet to the collagen g. platelet derived growth factor → healing.

✓ Contraction of platelet:

1. Release of platelet granule 2. Clot reaction.

Blood coagulation:

Formation of prothrombin activator (Thrombokinase complex) to convert prothrombin to Thrombin by P.A.

Fibringen → fibrin thread (These fibrin thread are cross linked, and protein become insoluble. / Coagulation occur by 2 ways:
1. intrinsic 2. Extrinsic / Fibrinolysis by: 1. intrinsic 2. extrinsic